# Torsion-rotation intensities in methanol

Completed Technology Project (2014 - 2016)

## Project Introduction

Methanol exists in numerous kinds of astronomical objects featuring a wide range of local conditions. The light nature of the molecule coupled with the internal rotation of the methyl group with respect to the hydroxyl group results in a rich, strong spectrum that spans the entire far-infrared region. As a result, any modest size observational window will have a number of strong methanol transitions. This has made it the gas of choice for testing THz receivers and to extract the local physical conditions from observations covering small frequency windows. The latter has caused methanol to be dubbed the 'Swiss army knife of astrophysics.' Methanol has been increasingly used in this capacity and will be used even more for subsequent investigations into the Herschel archive, and with SOFIA and ALMA. Interpreting physical conditions on the basis of a few methanol lines requires that the molecular data, line positions, intensities, and collision rates, be complete, consistent and accurate to a much higher level than previously required for astrophysics. The need for highly reliable data is even more critical for modeling the two classes of widespread maser action and many examples of optical pumping through the torsional bands. Observation of the torsional bands in the infrared will be a unique opportunity to directly connect JWST observations with those of Herschel, SOFIA, and ALMA. The theory for the intensities of torsion-rotation transitions in a molecule featuring a single internally rotating methyl group is well developed after 70 years of research. However, other than a recent very preliminary and not completely satisfactory investigation of a few CH3OH torsional bands, this theory has never been experimentally tested for any C3V internal rotor. More alarming is a set of recent intensity calibrated microwave measurements that showed deviations relative to calculations of up to 50% in some ground state rotational transitions commonly used by astronomers to extract local conditions. We propose a comprehensive study of the intensities of methanol involving both the pure rotation bands and the torsional bands to serve as a benchmark for the theory used to calculate the infrared activity of all single methyl internal rotation molecules.


Torsion-rotation intensities in methanol

## Table of Contents



## Organizational Responsibility

**Responsible Mission Directorate:**

Science Mission Directorate (SMD)

**Responsible Program:**

Astrophysics Research and Analysis

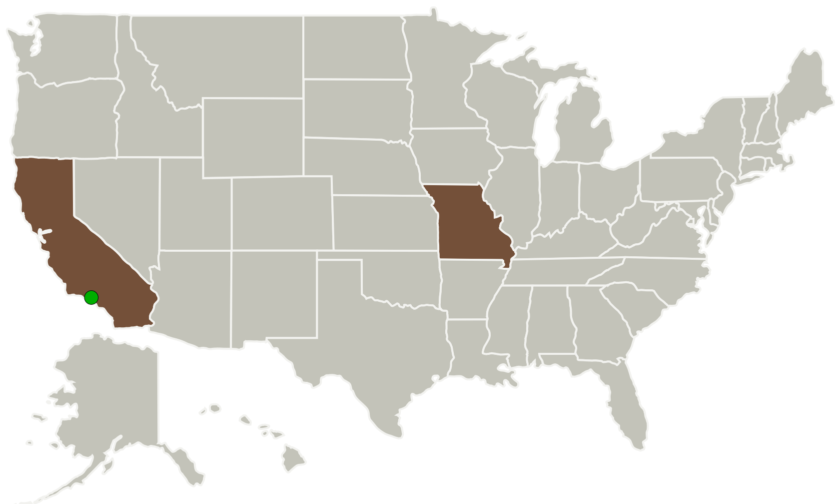
## Project Management

**Program Director:**

Michael A Garcia

*Continued on following page.*

## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| Jet Propulsion Laboratory(JPL) | Supporting Organization | NASA Center | Pasadena, California |
| University of Missouri-Kansas City | Supporting Organization | Academia | Kansas City, Missouri |

| Primary U.S. Work Locations | |
|---|---|
| California | Missouri |

## Project Management *(cont.)*

**Program Manager:**

Dominic J Benford

**Principal Investigator:**

John C Pearson

**Co-Investigators:**

Keeyoon Sung
Peter Groner
Brian J Drouin

## Technology Areas

**Primary:**

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  └ TX12.5 Structural Dynamics
    └ TX12.5.2 Vibroacoustics

## Target Destination

Outside the Solar System